

April 1996

Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

These reports are now available via the World Wide Web at <http://frf.wes.army.mil/frf.html>

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Your comments and criticisms are welcome.

Introduction

1

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511 (*c.baron@cerc.wes.army.mil*).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

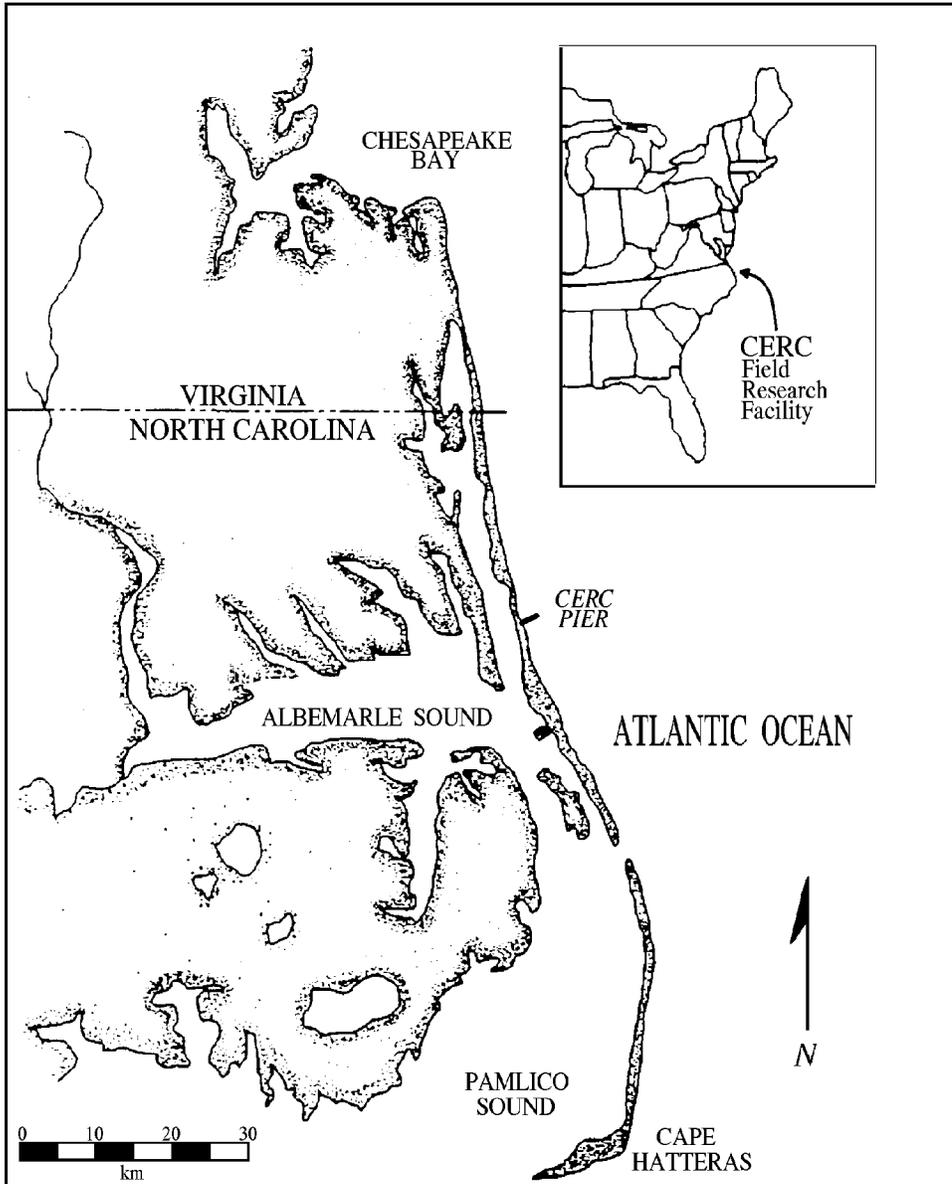


Figure 1. FRF Location Map

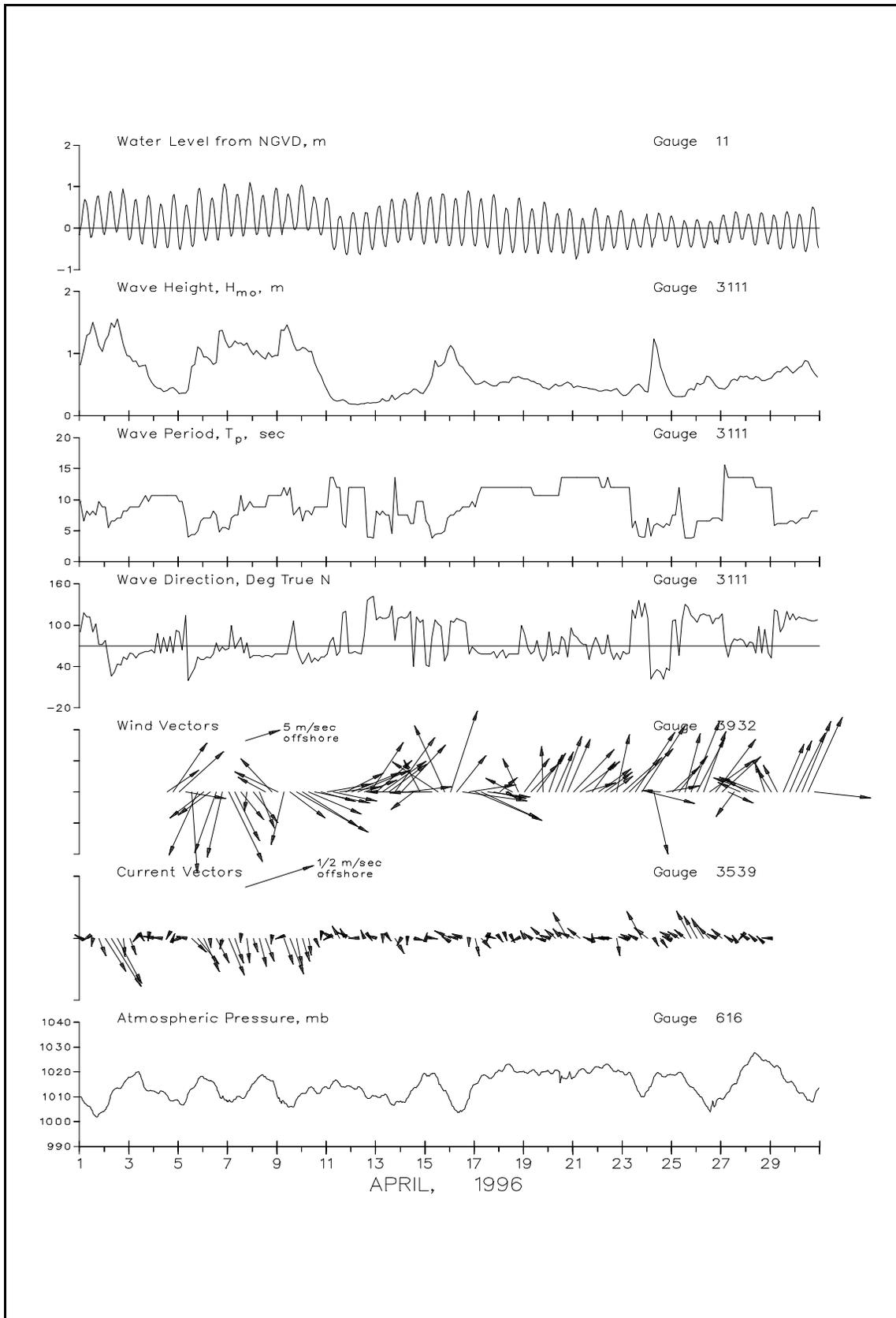


Figure 2. Month at a Glance

**Table 1
Instrument Status/Data Availability**

		April 1996		Day of the month																																				
Gauge ID	Description/Remarks			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31						
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
625	Baylor staff on FRF pier	Gauge Status	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		Data Collected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	/	/	*	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Gauge Status		*	=	Operational	/	=	Partial	-	=	Non-Operational																														
Data Collected		*	=	All	/	=	Partial	-	=	None																														
Visual Observations		*	=	Complete	/	=	Partial	-	=	None																														

**Table 2
Gauge Locations**

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crossshore T m	FRF Coordinates Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10' 57.03"	75 45' 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11' 1.23"	75 44' 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10' 57.71"	75 44' 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11' 1.04"	75 44' 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11' 19.14"	75 44' 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11' 11.28"	75 44' 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11' 13.70"	75 44' 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11' 12.48"	75 44' 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11' 14.06"	75 44' 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10' 5.10"	75 41' 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11' 23.57"	75 44' 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11' 1.25"	75 44' 42.60"	596.49	514.20	Surface	-7.62
R	R	R	R	R	R	R	R

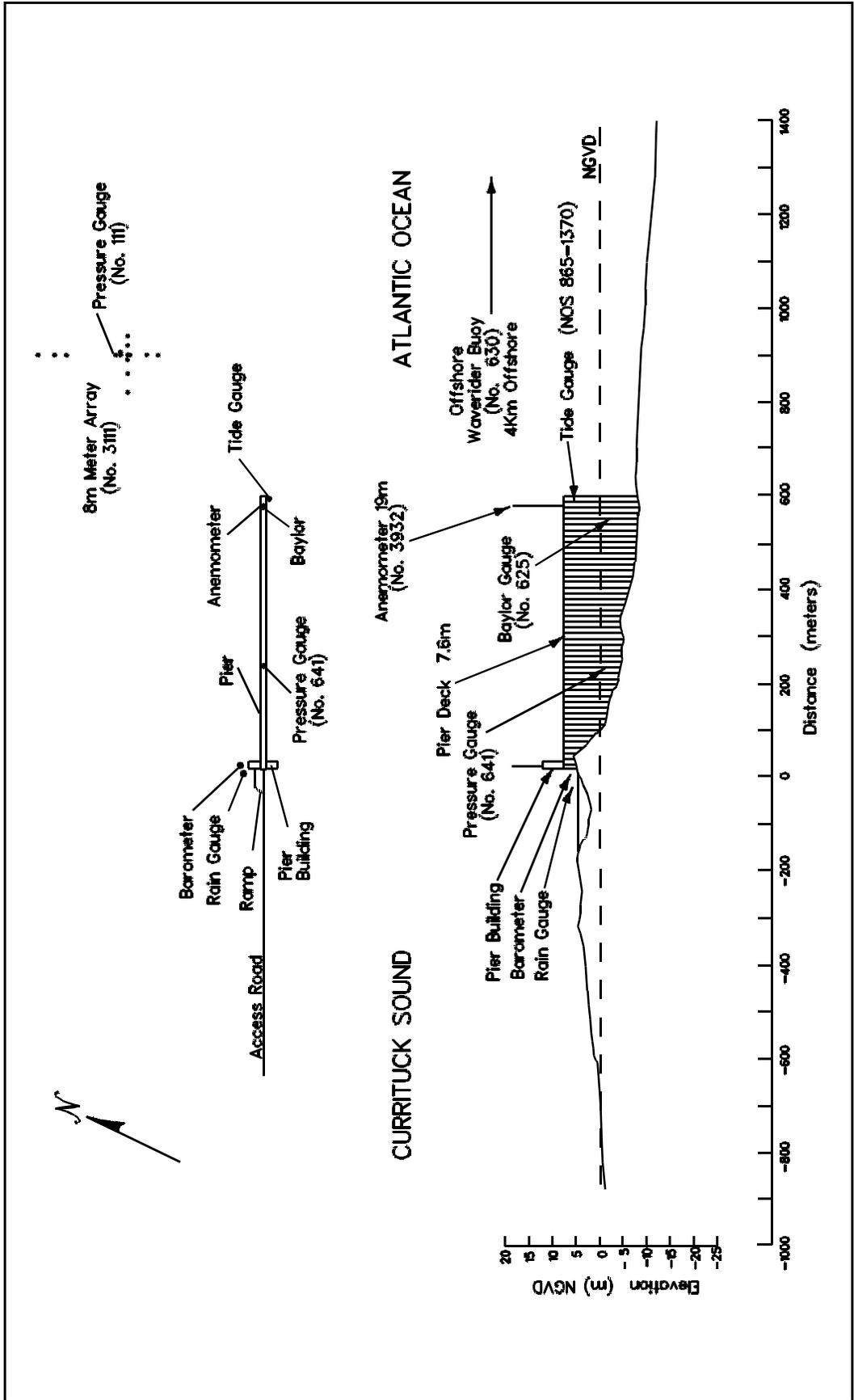


Figure 3. Instrument Locations, Elevations From NGVD

Meteorological Data

2

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -
 $\text{m/s} \times 1.943 = \text{kn}$

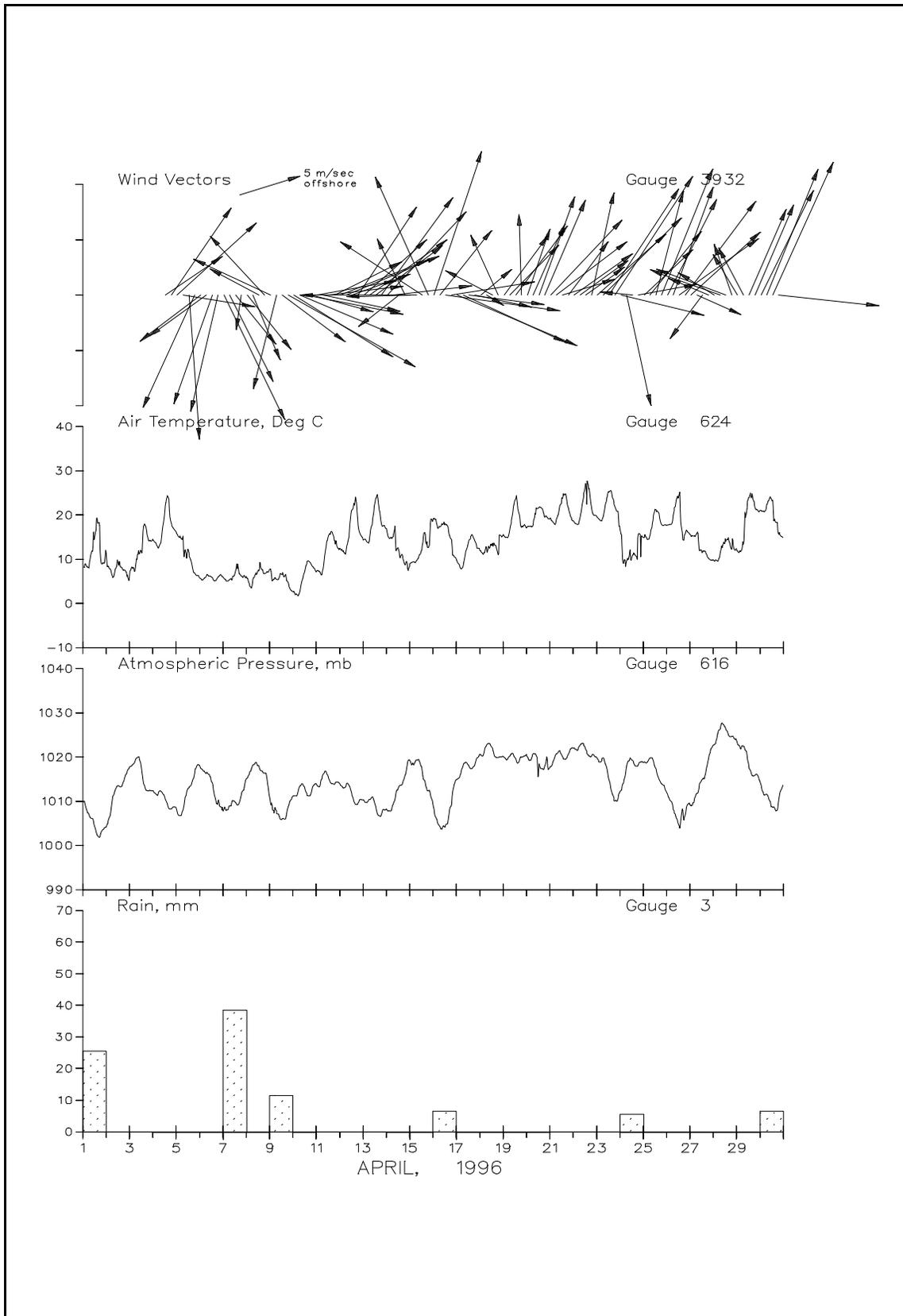


Figure 4. Meteorological Monthly Summary

**Table 3
Meteorological Data**

Apr 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100			8.1	1010.0	0
	700			9.4	1006.7	25
	1300			16.3	1003.8	0
	1900			9.2	1003.0	0
2	100			8.4	1004.8	0
	700			5.9	1011.1	0
	1300	inoperative		8.6	1013.5	0
	1900			7.5	1015.2	0
3	100			7.4	1017.8	0
	700			10.0	1019.8	0
	1300			11.4	1016.4	0
	1900			14.6	1012.4	0
4	100			14.2	1012.1	0
	700			13.3	1012.4	0
	1300	6	231	22.2	1010.5	0
	1900	9	210	18.1	1008.3	0
5	100	9	223	15.7	1007.9	0
	700	6	280	15.2	1008.0	0
	1300	13	356	11.3	1013.1	0
	1900	11	21	6.9	1016.4	0
6	100	6	48	5.6	1017.4	0
	700	6	50	6.1	1016.4	0
	1300	10	16	5.9	1014.3	0
	1900	11	11	6.0	1010.0	0
7	100	12	337	5.7	1008.3	0
	700	9	336	5.4	1009.0	38
	1300	5	324	7.4	1009.7	0
	1900	3	7	6.2	1011.4	0
8	100	6	325	5.6	1015.2	0
	700	6	340	5.4	1018.3	0
	1300	4	121	7.4	1018.1	0
	1900	7	141	6.8	1016.4	0
9	100	7	118	7.8	1009.6	0
	700	9	11	5.4	1007.8	11
	1300	6	310	6.6	1006.2	0
	1900	12	303	4.7	1008.9	0
10	100	9	305	2.7	1011.2	0
	700	8	1	2.6	1013.5	0
	1300	8	282	8.0	1012.4	0
	1900	5	287	8.7	1012.1	0

Table 3
Meteorological Data (continued)

Apr 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	6	258	7.5	1013.6	0
	700	6	283	7.9	1016.2	0
	1300	6	262	15.5	1015.1	0
	1900	6	239	14.1	1013.9	0
12	100	8	244	12.2	1013.7	0
	700	8	244	12.5	1014.0	0
	1300	5	247	21.1	1011.4	0
	1900	9	209	17.7	1009.6	0
13	100	7	224	14.4	1010.2	0
	700	8	230	15.0	1010.5	0
	1300	7	229	23.9	1008.8	0
	1900	10	212	18.1	1007.1	0
14	100	10	219	15.9	1008.0	0
	700	6	262	15.2	1009.5	0
	1300	4	47	11.8	1013.4	0
	1900	6	156	8.8	1016.0	0
15	100	5	88	9.1	1019.0	0
	700	9	89	9.7	1019.3	0
	1300	8	127	13.2	1016.8	0
	1900	11	158	12.6	1012.4	0
16	100	13	195	19.1	1008.4	0
	700	7	214	17.3	1004.3	6
	1300	9	279	17.9	1004.6	0
	1900	7	259	14.5	1009.3	0
17	100	10	296	9.5	1015.0	0
	700	9	1	8.6	1018.3	0
	1300	6	278	14.3	1018.1	0
	1900	5	1	14.1	1018.4	0
18	100	3	225	11.9	1020.6	0
	700	2	304	12.8	1022.6	0
	1300	4	121	13.7	1021.9	0
	1900	6	158	11.1	1019.9	0
19	100	6	212	15.2	1019.9	0
	700	6	220	16.7	1020.2	0
	1300	7	212	23.7	1019.6	0
	1900	7	178	17.1	1020.1	0
20	100	6	196	17.4	1020.0	0
	700	7	200	17.7	1020.8	0
	1300	9	197	*	1018.5	0
	1900	9	200	19.5	1017.9	0

**Table 3
Meteorological Data (concluded)**

Apr 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	9	219	19.1	1017.9	0
	700	7	228	19.0	1020.8	0
	1300	4	250	23.7	1020.2	0
	1900	6	212	21.5	1020.8	0
22	100	6	230	18.5	1022.1	0
	700	5	230	19.5	1022.7	0
	1300	4	230	27.1	1021.8	0
	1900	9	190	21.3	1020.3	0
23	100	8	223	19.5	1019.7	0
	700	9	221	19.7	1019.8	0
	1300	11	209	25.2	1014.9	0
	1900	12	209	21.8	1010.1	0
24	100	7	285	15.7	1012.5	0
	700	10	349	9.6	1018.1	5
	1300	3	96	11.0	1019.3	0
	1900	5	257	15.6	1018.3	0
25	100	6	222	14.9	1018.9	0
	700	7	214	15.3	1019.8	0
	1300	10	192	21.2	1017.4	0
	1900	12	199	17.8	1014.0	0
26	100	9	203	17.8	1011.6	0
	700	10	197	19.9	1008.2	0
	1300	8	230	24.7	1004.4	0
	1900	10	213	15.8	1007.0	0
27	100	8	223	15.3	1009.2	0
	700	4	1	15.9	1011.8	0
	1300	5	32	11.6	1015.1	0
	1900	3	1	10.2	1019.7	0
28	100	3	125	9.7	1022.8	0
	700	6	112	11.5	1026.3	0
	1300	6	113	14.0	1026.4	0
	1900	5	163	12.3	1024.7	0
29	100	4	152	12.0	1023.1	0
	700	5	155	13.4	1022.5	0
	1300	8	200	23.9	1017.5	0
	1900	9	200	21.6	1015.9	0
30	100	10	203	21.0	1013.7	0
	700	12	199	22.5	1011.6	6
	1300	13	201	23.3	1008.6	0
	1900	8	277	16.0	1009.8	0
		Resultant		Mean	Mean	Total
		4	226	13.7	1014.5	91

Wave Data

3

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4
Wave Data**

Apr 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	0.37	9.9	inoperative		0.81	9.8	90	0.91	9.9
	0700	0.85	7.2			1.29	8.2	112	1.54	7.4
	1300	0.98	7.8			1.50	8.2	90	1.71	8.1
	1900	0.64	7.2			1.13	9.8	72	1.40	9.2
2	0100	0.56	7.4			1.21	8.9	78	1.28	7.6
	0700	1.21	6.8			1.49	6.6	26	1.74	6.6
	1300	1.11	7.2			1.56	7.1	44	1.89	7.2
3	1900	1.04	7.4			1.14	8.2	54	1.26	8.1
	0100	0.68	7.2			0.95	8.9	60	1.00	8.1
	0700	0.62	6.3			0.88	8.9	52	0.95	8.9
4	1300	0.45	9.5			inoperative			0.92	8.3
	1900	0.37	11.2			0.63	9.8	62	0.90	10.3
	0100	0.19	9.9			0.47	10.8	60	0.64	10.7
	0700	0.27	7.8			0.44	10.8	60	0.66	10.7
	1300	0.21	5.6			0.40	10.8	62	0.53	10.7
5	1900	0.31	6.5			0.45	10.8	60	0.71	4.0
	0100	0.21	6.1	inoperative		0.36	9.8	90	0.54	9.2
	0700	0.22	6.6			0.37	7.1	114	0.47	6.5
	1300	0.65	4.3			0.79	4.4	30	1.03	4.1
6	1900	0.82	5.2			1.10	5.0	54	1.28	5.0
	0100	0.76	7.0			0.95	7.1	50	1.20	6.6
	0700	0.67	6.3			0.90	7.1	52	1.02	7.4
	1300	0.51	6.1			0.85	7.6	74	1.01	8.1
7	1900	0.97	5.2			1.38	5.6	68	1.57	5.3
	0100	0.73	4.9			1.10	5.3	66	1.33	5.1
	0700	0.71	5.3			1.20	7.6	66	1.38	6.8
8	1300	0.65	11.7			1.17	10.8	82	1.35	11.2
	1900	0.75	8.9			1.17	8.9	74	1.19	8.9
	0100	0.67	9.5			0.99	8.9	56	0.96	9.2
	0700	0.78	5.5			0.99	8.9	56	1.13	7.0
	1300	0.66	5.6			0.91	8.9	56	0.99	8.9
9	1900	0.64	9.9			0.94	10.8	54	1.08	10.3
	0100	0.67	11.2			0.97	10.8	58	1.12	10.7
	0700	0.97	5.5			1.37	12.0	58	1.49	11.2
	1300	0.98	11.7			1.34	12.0	78	1.50	7.8
10	1900	0.73	8.3			1.05	8.2	66	1.25	8.1
	0100	0.92	6.6	inoperative		1.10	6.6	44	1.27	8.6
	0700	0.93	7.8			1.03	8.2	60	1.24	8.1
	1300	0.80	7.8			0.86	8.9	52	1.05	8.1
	1900	0.50	5.5			0.64	8.9	54	0.70	9.5

**Table 4
Wave Data (continued)**

Apr 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
11	0100	0.37	8.6	inoperative		0.41	8.9	58	0.50	9.2
	0700	0.15	13.5			0.26	13.6	82	0.34	12.9
	1300	0.18	5.3			0.24	12.0	62	0.35	5.1
	1900	0.15	5.3			0.24	5.6	120	0.32	4.8
12	0100	0.15	4.4			0.19	12.0	60	0.34	4.1
	0700	0.11	5.0			0.17	12.0	60	0.33	2.2
	1300	0.14	11.7			0.19	12.0	86	0.25	4.0
	1900	0.15	5.4			0.20	4.1	140	0.44	3.5
13	0100	0.16	6.5			0.21	8.2	108	0.35	7.4
	0700	0.20	7.8			0.27	8.2	110	0.46	8.1
	1300	0.19	7.4			0.25	7.6	112	0.35	7.4
	1900	0.25	5.2			0.26	13.6	78	0.60	4.6
14	0100	0.27	7.4			0.34	7.6	112	0.55	7.6
	0700	0.26	5.1			0.34	7.6	112	0.45	5.9
	1300	0.32	6.0			0.43	6.2	40	0.48	6.5
	1900	0.30	6.3			0.37	9.8	104	0.51	6.1
15	0100	0.28	8.9	inoperative		0.43	6.6	42	0.52	6.6
	0700	0.56	3.5			0.63	3.9	84	0.88	3.4
	1300	0.62	4.6			0.80	4.6	102	0.97	4.8
	1900	0.57	5.0			0.87	5.0	48	1.14	5.0
16	0100	0.77	7.6			1.13	7.6	106	1.36	7.8
	0700	0.65	8.1			0.91	8.2	110	1.18	8.1
	1300	0.44	8.6			0.78	8.9	106	0.98	8.3
	1900	0.44	8.3			0.64	8.9	58	0.86	9.2
17	0100	0.30	9.2			0.50	8.9	64	0.69	9.9
	0700	0.36	11.7			0.52	12.0	58	0.77	11.2
	1300	0.30	11.7			inoperative			0.65	11.7
	1900	0.29	11.7			0.47	12.0	62	0.55	11.7
18	0100	0.25	11.7			0.53	12.0	60	0.49	11.2
	0700	0.30	12.2			0.54	12.0	52	0.50	12.2
	1300	0.28	12.9			0.61	12.0	58	0.55	11.7
	1900	0.39	12.2			0.63	12.0	58	0.65	12.2
19	0100	0.25	11.7			0.59	12.0	88	0.62	11.7
	0700	0.32	10.7			0.55	12.0	58	0.55	11.7
	1300	0.22	12.2			0.52	10.8	78	0.52	11.2
	1900	0.25	11.7			0.45	10.8	48	0.55	9.9
20	0100	0.21	11.7	inoperative		0.42	10.8	90	0.46	11.2
	0700	0.29	5.5			0.51	10.8	62	0.61	12.9
	1300	0.30	5.9			0.48	13.6	84	0.70	5.4
	1900	0.35	6.1			0.54	13.6	54	0.83	6.0

**Table 4
Wave Data (concluded)**

Apr 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
21	0100	0.29	7.2	inoperative		0.46	13.6	86	0.58	7.0
	0700	0.30	6.6			0.47	13.6	76	0.58	5.9
	1300	0.27	6.8			0.46	13.6	72	0.55	6.0
	1900	0.26	6.0			0.43	13.6	68	0.51	12.2
22	0100	0.26	6.0			0.40	13.6	72	0.47	13.5
	0700	0.26	6.0			0.41	12.0	60	0.49	6.1
	1300	0.24	12.9			0.39	12.0	62	0.44	12.9
	1900	0.32	3.9			0.43	12.0	60	0.62	3.9
23	0100	0.20	11.7			0.32	12.0	62	0.50	12.2
	0700	0.21	6.5			0.37	12.0	60	0.47	6.6
	1300	0.35	6.6			0.48	6.6	110	0.74	6.5
	1900	0.34	4.9			0.46	4.1	112	0.84	4.1
24	0100	0.26	5.5			0.38	7.1	110	0.47	7.0
	0700	1.06	5.9			1.24	5.9	30	1.49	5.5
	1300	0.82	5.7			0.79	5.9	32	0.97	6.0
	1900	0.45	5.7			0.50	6.2	38	0.69	6.3
25	0100	0.28	5.5	inoperative		0.33	7.6	106	0.41	7.4
	0700	0.18	7.0			0.31	12.0	56	0.35	7.6
	1300	0.25	7.2			0.32	3.9	130	0.57	3.2
	1900	0.34	5.1			0.44	3.9	114	0.83	4.7
26	0100	0.42	6.3			0.53	6.6	104	0.76	6.1
	0700	0.37	6.5			0.52	6.6	116	0.74	6.1
	1300	0.50	6.6			0.62	6.6	114	0.87	7.2
	1900	0.36	7.4			0.48	7.1	110	0.64	6.8
27	0100	0.31	6.5			0.44	6.6	116	0.55	6.8
	0700	0.28	7.2			0.48	13.6	54	0.56	7.4
	1300	0.39	13.5			0.59	13.6	80	0.64	14.3
	1900	0.38	13.5			0.64	13.6	80	0.66	14.3
28	0100	0.38	13.5			0.63	13.6	68	0.67	12.9
	0700	0.37	12.9			0.59	13.6	74	0.68	12.2
	1300	0.39	12.2			0.61	12.0	98	0.70	11.7
	1900	0.37	12.2			0.56	12.0	94	0.65	12.9
29	0100	0.36	5.5			0.61	12.0	52	0.72	12.2
	0700	0.46	6.1			0.71	6.2	120	0.91	6.5
	1300	0.52	6.1			0.76	6.2	98	0.96	6.3
	1900	0.59	6.5			0.74	6.6	108	0.99	6.6
30	0100	0.51	6.1	inoperative		0.73	6.2	108	0.97	6.5
	0700	0.59	7.2			0.80	7.1	110	1.07	6.6
	1300	0.64	7.4			0.87	7.1	108	1.27	7.6
	1900	0.47	7.8			0.68	8.2	106	0.88	7.2
Mean		0.46	7.8	0.00	0.0	0.66	9.3	76	0.82	8.1
Std dev		0.25	2.6	0.00	0.0	0.33	2.8	25	0.36	2.8

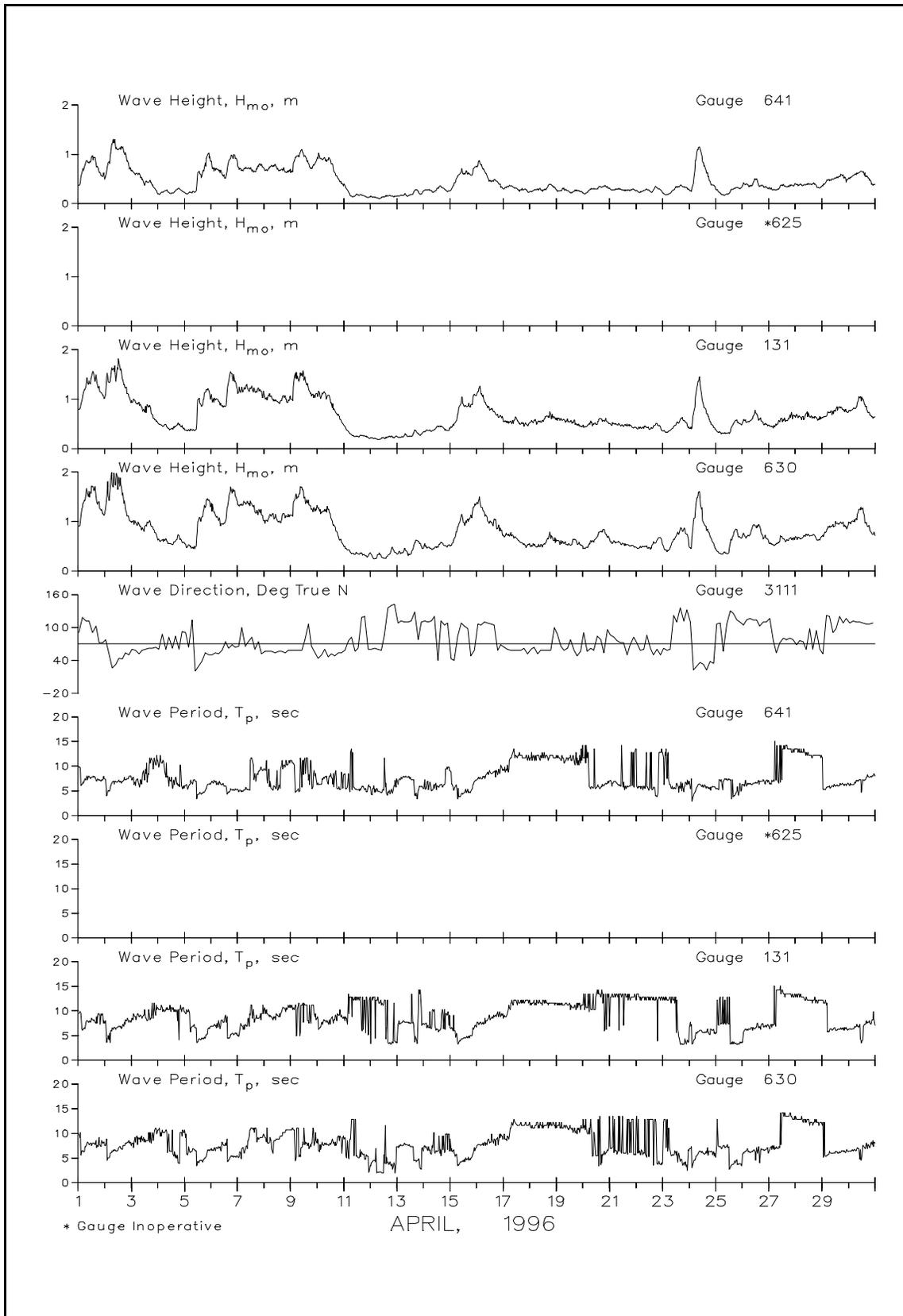


Figure 5. Wave Heights and Periods

Current Data

4

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

Table 5
Current Meter Data - Gauge 3539

APRIL 1996																	
Cross Long					Cross Long					Cross Long							
Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100	3	-3	5	302	11	100	3	1	3	235	21	100	8	-7	11	294
	700	3	1	3	231		700	7	-7	10	301		700	6	-9	12	312
	1300	4	6	7	191		1300	1	-10	11	333		1300	2	-1	3	296
	1900	1	15	15	162		1900	1	-7	8	331		1900	0	-2	4	349
2	100	-3	30	30	152	12	100	8	-7	11	295	22	100	3	0	3	274
	700	-5	43	44	152		700	6	-1	6	266		700	4	-1	4	275
	1300	-2	40	40	155		1300	0	-6	7	340		1300	inoperative			
	1900	4	14	15	177		1900	0	2	2	148		1900	3	14	14	172
3	100	1	14	14	163	13	100	6	-3	7	288	23	100	3	-1	3	285
	700	3	2	4	218		700	1	4	4	180		700	5	-4	7	296
	1300	0	3	3	155		1300	0	3	3	149		1300	4	-3	6	300
	1900	1	2	2	188		1900	-1	14	14	154		1900	2	-23	24	334
4	100	7	-3	8	279	14	100	5	4	7	207	24	100	6	-10	13	311
	700	5	-2	6	275		700	2	5	6	185		700	0	7	7	155
	1300	1	1	1	205		1300	-5	4	8	105		1300	-1	9	9	148
	1900	-1	-2	3	17		1900	inoperative					1900	2	-1	3	297
5	100	6	1	6	242	15	100	-1	-3	4	12	25	100	6	-7	10	300
	700	5	-2	6	282		700	-2	2	4	101		700	5	-6	9	304
	1300	-5	14	15	138		1300	inoperative					1300	4	-8	10	313
	1900	-6	25	26	145		1900	1	-1	2	308		1900	2	-23	24	335
6	100	0	29	29	158	16	100	8	-8	12	298	26	100	3	-19	20	333
	700	2	7	8	177		700	5	-3	6	285		700	2	-17	18	333
	1300	-1	21	21	155		1300	6	-5	8	296		1300	5	-11	12	319
	1900	5	8	9	191		1900	3	6	7	183		1900	4	-4	7	301
7	100	0	32	32	160	17	100	2	14	15	169	27	100	4	-8	10	314
	700	1	21	21	163		700	-2	9	10	142		700	2	-2	3	308
	1300	1	3	3	184		1300	2	2	3	195		1300	1	-2	3	330
	1900	5	19	20	175		1900	0	1	1	110		1900	1	1	2	216
8	100	1	12	12	164	18	100	0	4	4	146	28	100	3	-4	5	310
	700	3	23	23	168		700	0	2	2	165		700	2	-3	4	317
	1300	1	20	20	162		1300	0	4	4	155		1300	1	-1	2	318
	1900	2	4	5	186		1900	6	1	6	243		1900	2	0	2	273
9	100	2	0	2	247	19	100	1	-6	7	332	29	100				
	700	1	22	22	163		700	3	-4	6	310		700				
	1300	1	30	30	162		1300	1	0	1	290		1300				
	1900	4	22	22	170		1900	5	-10	12	316		1900	inoperative			
10	100	2	19	19	166	20	100	5	-3	6	289	30	100				
	700	3	14	14	172		700	5	-8	10	313		700				
	1300	0	8	8	159		1300	3	-8	9	321		1300				
	1900	1	1	1	184		1900	3	-22	23	334		1900				

KEY:
 +cross-shore = offshore, cm/sec
 -cross-shore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

Apr 1996												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	2	-13	13	349	0	-44	44	340	South	40	N	
2	0	87	87	160	-6	55	56	166	North	113	N	
3	3	20	20	151	0	21	21	160	North	17	N	
4	19	-8	21	48	1	-8	9	349	South	9	S	
5	5	8	9	129	6	11	12	133	North	5	S	
6	-7	44	44	169	-20	102	104	171	North	22	S	
7	6	41	41	151	5	47	47	154	North	19	S	
8	-8	25	27	177	-10	34	35	177	North	12	S	
9	0	55	55	160	0	41	41	160	North	16	S	
10	8	41	41	149	-9	44	44	250	North	8	S	
11	30	30	43	70	14	19	24	123		no observation		
12	16	16	23	115	16	16	23	115		no observation		
13	20	15	25	70	12	-30	33	2	South	9	N	
14	5	-11	12	7	3	-15	16	351	South	0		
15	-11	15	19	250	-9	15	18	250	South	3	N	
16	10	-28	29	359	5	-30	31	349	South	55	N	
17	24	28	36	120	4	18	18	149	North	17	S	
18	0	16	16	160	0	9	9	160	North	5	N	
19	14	-19	24	17	30	-8	31	54	South	12	N	
20	0	-32	32	340	5	-19	20	354	South	15	N	
21	15	-15	22	25	3	-28	28	346	South	17	N	
22	9	-15	17	11	2	-15	15	346	South	0		
23	9	-23	25	2	8	-27	28	357	South	15	S	
24	0	34	34	160	0	55	55	160	North	52	N	
25	4	-25	26	349	0	-12	12	340	South	5	S	
26	4	-29	29	349	0	-47	47	340	South	26	N	
27	10	13	17	70	2	-10	10	351	South	29	N	
28	-7	-12	14	309	-5	-8	9	307	North	50	N	
29	-1	-5	5	323	-1	-29	29	337	South	58	N	
30	0	-51	51	340	2	-32	32	343	South	82	N	

KEY:
+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

Visual Observations

5

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Apr 1996

Day	Time	Wave Approach Angle at Pier End deg from True N		Width of Surf Zone,m	Water Characteristics at Pier End		
		Primary	Secondary		Temp.,C	Density g/cc	Secchi Vis.,m
1	0725	105		195	7.2	1.0226	0.6
2	0720	20		166	8.9	1.0211	0.9
3	0715	35	65	34	8.1	1.0212	0.6
4	0745	80		15	6.9	1.0243	0.6
5	0715	100	75	5	6.7	1.0260	1.2
6	0844	45		43	8.9	1.0206	1.8
7	0926	75	45	46	8.3	1.0204	1.2
8	0733	60		70	7.8	1.0214	1.2
9	0741	65	45	178	7.8	1.0232	0.6
10	0703	60	35	149	7.2	1.0234	0.9
11	0636	65		24	7.2	1.0240	1.2
12	0638	none	visible	37	7.8	1.0244	2.1
13	0940	none	visible	12	8.3	1.0258	2.4
14	1110	80		24	9.4	1.0252	3.7
15	0700	70		35	10.3	1.0232	2.1
16	0715	110		30	7.8	1.0243	2.1
17	0715	20		20	7.2	1.0261	1.5
18	0610	70	140	14	9.4	1.0237	2.7
19	0615	70	140	20	9.4	1.0236	0.9
20	0600	70	120	26	7.5	1.0250	1.8
21	0630	130		27	7.8	1.0256	3.0
22	0600	110		21	8.3	1.0259	3.0
23	0600	125		24	8.3	1.0256	3.0
24	0630	30		155	8.1	1.0257	2.1
25	0600	80	120	23	8.1	1.0260	2.7
26	0625	120	70	27	9.4	1.0254	1.8
27	0600	105	140	32	10.0	1.0255	2.4
28	0640	85	50	148	10.6	1.0255	2.7
29	0600	110		30	11.7	1.0243	1.8
30	0645	120		41	11.1	1.0255	1.2

Water Levels

6

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

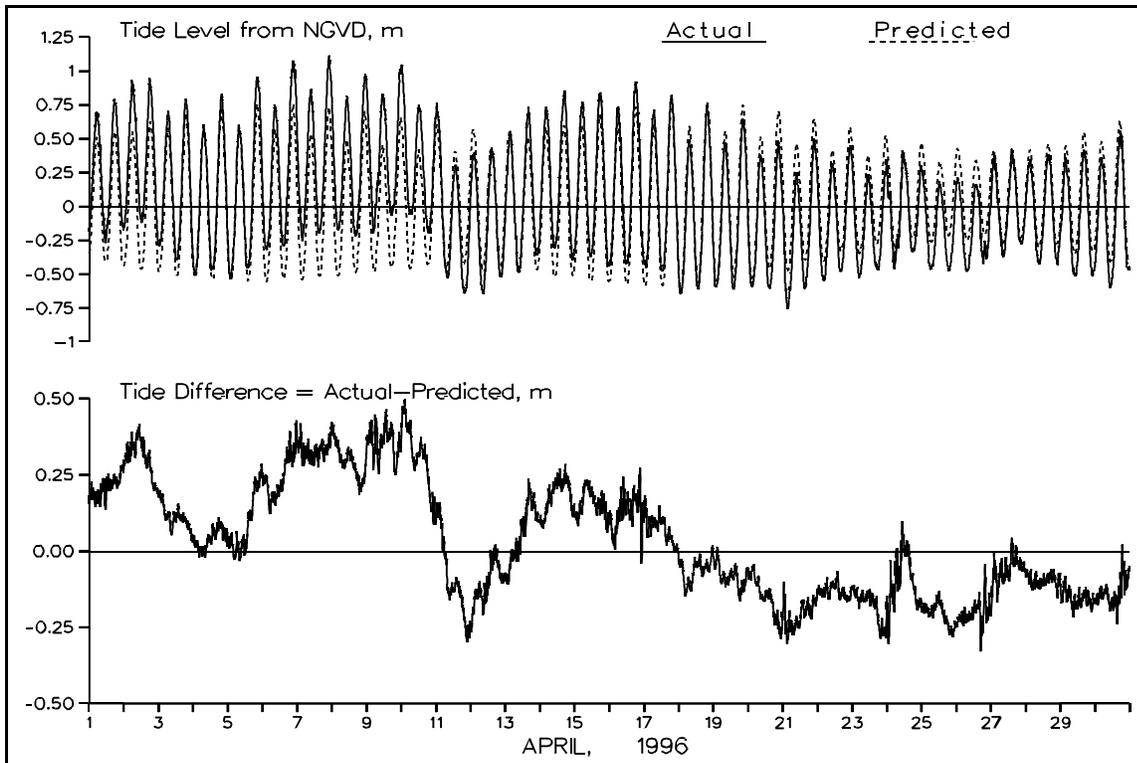


Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

APR 1996 Tide Levels															
Day	High		Day	Low		Mean m	Range m	Day	High		Day	Low		Mean m	Range m
	Time	m		Time	m				Time	m		Time	m		
1	0500	0.70	1	0006	-0.18	0.38	0.88	16	0606	0.74	15	2312	-0.44	0.13	1.18
1	1748	0.79	1	1118	-0.27	0.29	1.06	16	1812	0.93	16	1136	-0.43	0.25	1.36
2	0536	0.93	1	2354	-0.17	0.38	1.11	17	0648	0.72	17	0118	-0.45	0.11	1.16
2	1800	0.95	2	1224	-0.12	0.39	1.07	17	1906	0.82	17	1242	-0.48	0.16	1.30
3	0654	0.70	3	0042	-0.29	0.19	1.00	18	0706	0.49	18	0112	-0.64	-0.07	1.13
3	1906	0.80	3	1242	-0.40	0.20	1.19	18	1936	0.74	18	1330	-0.61	0.07	1.35
4	0718	0.61	4	0130	-0.51	0.06	1.12	19	0742	0.47	19	0136	-0.60	-0.06	1.07
4	1942	0.83	4	1300	-0.47	0.16	1.30	19	2006	0.65	19	1348	-0.61	0.02	1.26
5	0736	0.61	5	0154	-0.53	0.05	1.13	20	0842	0.38	20	0242	-0.59	-0.11	0.97
5	2042	0.96	5	1324	-0.46	0.26	1.42	20	2024	0.49	20	1506	-0.61	-0.07	1.10
6	0824	0.75	6	0248	-0.32	0.21	1.07	21	0942	0.25	21	0330	-0.76	-0.24	1.01
6	2048	1.08	6	1418	-0.29	0.41	1.37	21	2130	0.50	21	1500	-0.61	-0.05	1.11
7	0924	0.87	7	0336	-0.26	0.33	1.13	22	1012	0.32	22	0400	-0.55	-0.11	0.87
7	2206	1.12	7	1530	-0.20	0.45	1.32	22	2242	0.45	22	1542	-0.48	-0.02	0.93
8	1024	0.81	8	0424	-0.17	0.31	0.99	23	1124	0.24	23	0442	-0.53	-0.13	0.77
8	2306	0.97	8	1624	-0.22	0.38	1.19	23	2336	0.35	23	1736	-0.47	-0.09	0.82
9	1106	0.83	9	0442	-0.19	0.36	1.03	24	1054	0.41	24	0500	-0.46	-0.01	0.88
10	0012	1.05	9	1712	-0.06	0.47	1.11	24	2342	0.31	24	1742	-0.34	-0.04	0.64
10	1200	0.75	10	0654	-0.06	0.33	0.81	25	1200	0.19	25	0624	-0.46	-0.15	0.65
11	0048	0.76	10	1848	-0.20	0.27	0.96	26	0100	0.21	25	1906	-0.48	-0.13	0.69
11	1342	0.31	11	0806	-0.53	-0.09	0.84	26	1348	0.17	26	0712	-0.48	-0.16	0.65
12	0230	0.40	11	1942	-0.64	-0.12	1.04	27	0212	0.40	26	1836	-0.43	-0.03	0.83
12	1430	0.44	12	0842	-0.65	-0.08	1.08	27	1412	0.42	27	0830	-0.38	0.02	0.80
13	0324	0.53	12	2042	-0.53	0.01	1.06	28	0248	0.35	27	2118	-0.28	0.03	0.63
13	1618	0.73	13	0912	-0.48	0.12	1.21	28	1524	0.39	28	0918	-0.43	-0.01	0.81
14	0406	0.73	13	2130	-0.36	0.19	1.09	29	0336	0.36	28	2148	-0.43	-0.03	0.79
14	1700	0.86	14	1012	-0.31	0.27	1.17	29	1612	0.42	29	1012	-0.52	-0.06	0.94
15	0524	0.77	14	2248	-0.40	0.20	1.17	30	0448	0.36	29	2212	-0.51	-0.08	0.87
15	1742	0.84	15	1106	-0.37	0.23	1.21	30	1724	0.56	30	1036	-0.60	-0.02	1.16

Bathymetry

7

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in March 1996 and the survey(s) in April 1996 on profile line 188, located 517 m south of the pier.

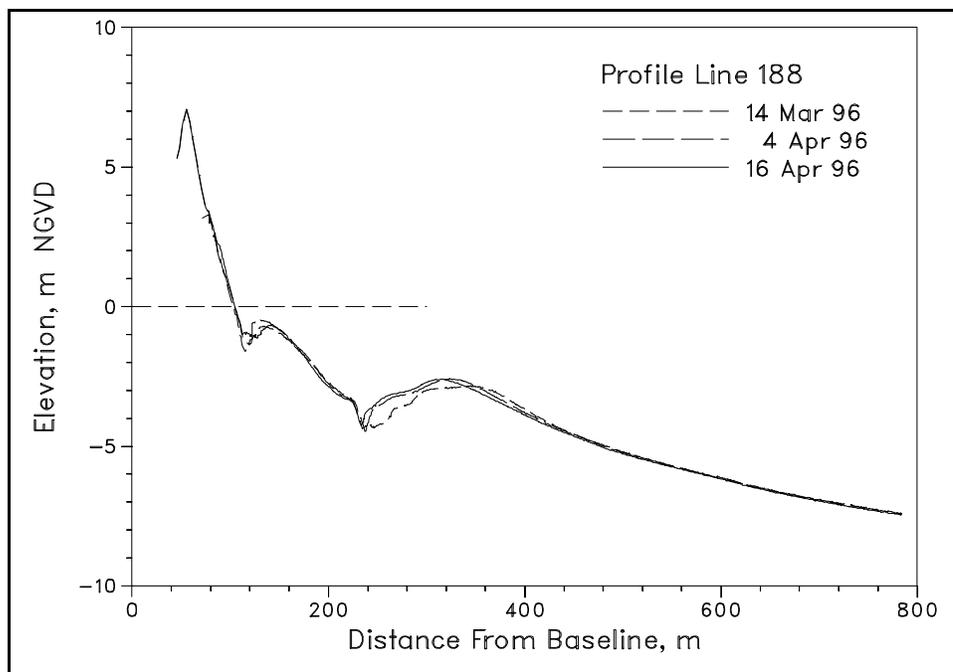


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1996. Cross-hatched areas indicate changes to the annual envelope which occurred in April.

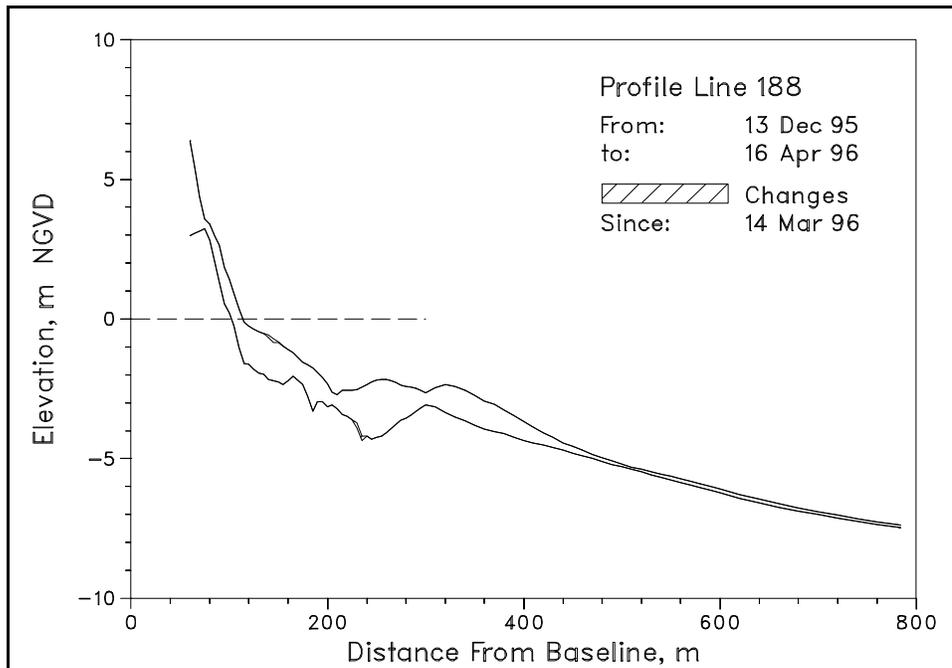
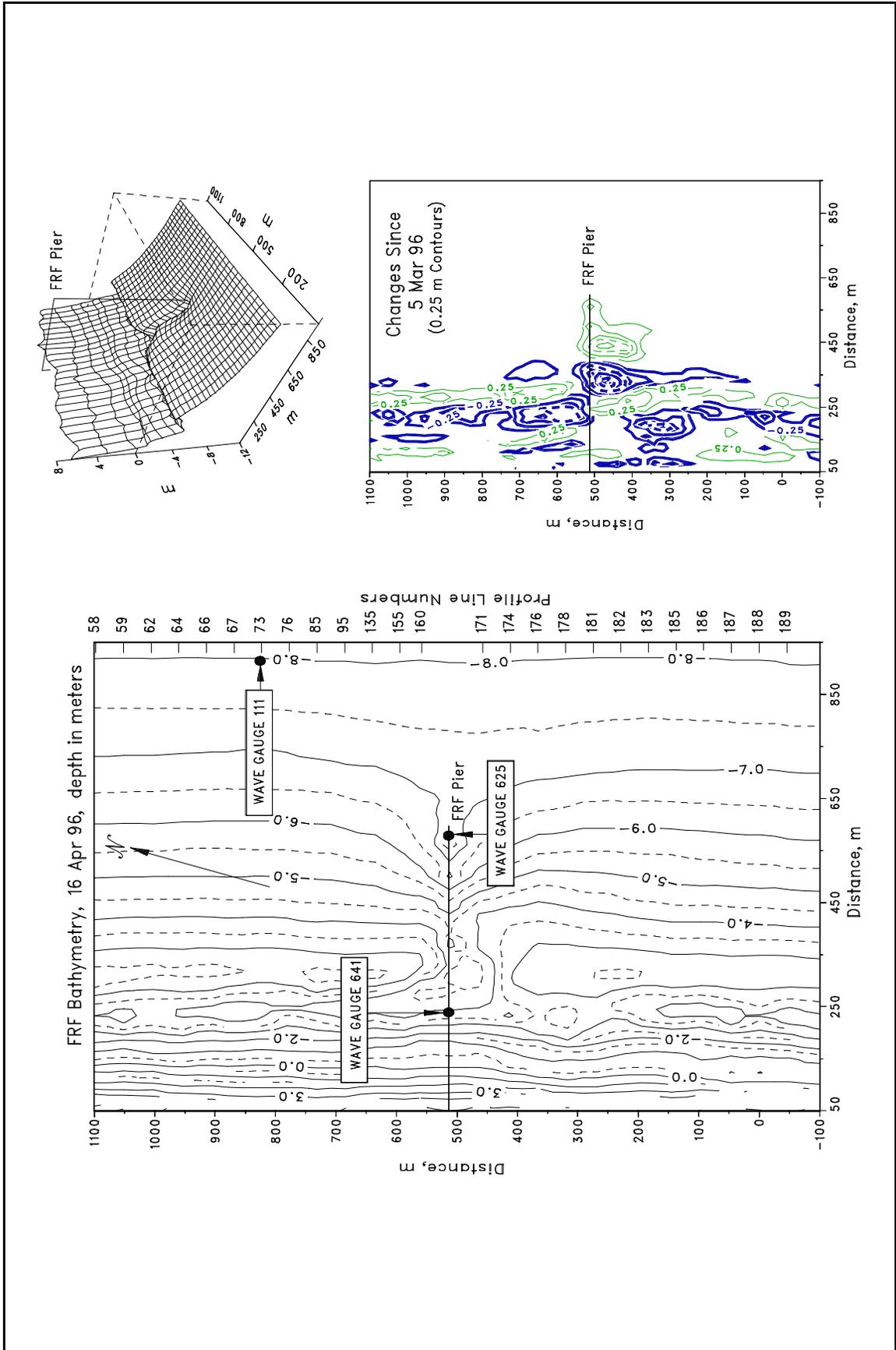


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 16 April. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



Special Events

8

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier exceeded 2 m.

<u>Start</u>	<u>End</u>
** Dec (0000)	** Dec (0000)

B. Storm Synopsis.

Northeasterly winds were funneled between a Canadian high pressure system and a low pressure system over Cape Hatteras. Winds intensified as the low pressure system moved along the North Carolina coast and began moving out to sea by the morning of ** April. Maximum onshore winds (NE) reached ** m/s at 0000 EST on ** April. The minimum atmospheric pressure was *** mb. The maximum H_{mo} , at gauge 630, reached *.* m ($T_p=**.*$ s) at 0000 EST on ** April. There was * mm of precipitation.